Therapeutic Exercise in General Practice

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• **Newer techniques of exercise which rely on a static or isometric muscle contraction of six seconds' duration once daily offer great possibilities in the treatment of patients incapacitated by low cardiac reserve, joints that are painful on movement or debility too severe to permit a conventional exercise program for general conditioning. Increments of strength of up to two per cent per day can be thus achieved in normal muscles. Muscles deconditioned by immobilization respond at a faster rate. However, no significant muscle hypertrophy can be achieved by this technique.**

This form of exercise can also be used by persons who are "too busy to exercise" but who may be willing to give two minutes a day to an exercise program designed to increase and maintain muscle tone and strength.

A considerable number of medical conditions could be treated more effectively and with less resultant disability if therapeutic exercises—passive, active and progressive—were accurately prescribed and supervised by a physician as part of the treatment program. Among the many conditions to be considered are poliomyelitis, peripheral nerve injuries, the neuritides, postural defects and cardiac diseases.

PHYSICIANS PRESCRIBING THERAPEUTIC EXERCISE sometimes have to cope with problems related to lack of adequate numbers of therapists to treat all patients, or pain so severe as to preclude conventional exercise, or debility so far advanced that therapeutic exercise has to be done with minimal expenditure of energy.

Searching for possible answers to these problems, I have drawn from experiences of European and American investigators and have incorporated some of my own. The discussion deals with the concept of a single daily maximal isometric contraction as a strength-developing technique, the phenomenon of cross transfer of strength and a consideration of three factors of importance in formulating an exercise program: Rate of exercise, total work involved and daily increments in resistance.

In 1953 Hettinger and Muller,[5] after working with young adults, postulated that increases in strength of 5 per cent per week can be obtained by employing a 6-second maximal isometric contraction once daily. Subsequent work by these investigators[9] led them to the following conclusions:

1. This increase in strength is possible even when the training load is as little as one-third of maximal strength.
2. Muscle strength increases more rapidly with increasing intensity of training load up to about two-thirds of maximal strength.
3. One practice period per day in which the tension is held for six seconds results in as much increase in strength as longer periods (up to full exhaustion) and more frequent exercise.
4. A muscle trained to a high level of performance can be maintained indefinitely at this level by one maximal contraction effort per week.
5. Loss of strength in strict inactivity is about four times as rapid as the loss from a trained muscle after the end of training. The speed of regaining strength after a period of inactivity and atrophy is also four times the speed of the increase in strength in training a normal muscle.
6. The atrophy-preventing effect persists in older people whereas the training effect is lost.

A year later (1954) reports from American investigators who had been assessing the merits of the Hettinger and Muller method of strength development began appearing in the literature. Some modifications were introduced by each investigator in conducting his experiments, but in general the results obtained tended to confirm the validity of the concept of isometric exercises[8,10,13,16] as an effective device for strength gaining. Mathews and Kruse[8] found that isometric exercise caused a greater increase in muscular strength than did isotonic movements, even though the time spent in the isometric exercise program was considerably less. In studying the effectiveness of various work periods, they found the 5-day exercise program to be superior to programs consisting of two, three or four exercise periods a week. Rarick and Larsen[10] compared the effectiveness of daily 6-second isometric contractions employing two-thirds maximal strength with that achieved by increasing the frequency of the bouts at tension levels of 80 per cent of maximal strength. They found that the exercise program involving greater tension levels and multiple daily bouts showed no significantly greater gains than those employing the single daily contraction.

Rose[13] brought about steady increases in strength in the exercised muscles by the use of a single 6-

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second sustained isotonic contraction of the quadriceps femoris. He also noted that daily increments of 1¼ pounds appeared to be optimal for strength gaining. These increments appeared to be independent of the original strength. In his opinion this substantiated the postulate of Hellebrandt[3] that strength is a learned act and the ability to handle increased weights is cerebral in origin rather than muscular. Rose also found that, once optimal strength is attained, it can be maintained by training as infrequently as once a month. He pointed to this fact as additional proof that strength is a learned act.

Rasch and Morehouse,[11] testing the effectiveness of a 15-second isometric contraction at two-thirds maximal tension, found no significant gains after a six weeks training period of three days a week. A single training period of isotonic exercises resulted in an increase of 14 pounds in elbow flexion strength, which was not retained when tested six weeks after cessation of exercises. This was the only published study that could be found which contradicts the findings of Hettinger and Muller.

Walters, Stewart and Le Claire[16] studied three different methods of developing elbow strength of the preferred arm. The subjects were young, healthy adults. Subjects in one group practiced holding full isometric tension each day; those in a second group held two-thirds of full isometric tension and those of the third group lifted one-third of the one-lift maximum as often as they could in a period of 15 seconds. The results of this study point to the following conclusions. (1) All the methods are effective in the development of strength and its retention; (2) the full isometric method is superior to the two-thirds method in strength development; (3) endurance tends to improve in both the preferred and non-preferred arms after training; and, (4) there is an improvement in strength in the non-preferred arm by all methods of training.

As a challenge to the contention of Hettinger and Muller that only the atrophy-preventing effect persists in older people, the author studied the performance of 20 members of the Soldiers Domiciliary of the Veterans Administration Hospital in Los Angeles. The average age of the group was 69 years (range 55-81). The subjects had serious disabilities, including arteriosclerotic heart disease, myocardial ischemia and Laennec's cirrhosis. The flexors and extensors of the legs and arms were exercised isometrically for six seconds daily five days a week. Since four muscle groups were exercised successively, the exercise time was 24 seconds daily. Patients were tested at the end of six weeks. The group registered an average gain in strength of 8.95 pounds in the arm flexors and 4.65 pounds in the arm extensors. Improvement in the strength of leg muscles was greatest in the flexors, the average gain being 16.5 pounds (range, 6 to 35 pounds). The average gain of the extensors was 10.3 pounds (range, 16 to 30 pounds). At the completion of the six weeks of 5-day a week exercises, patients were given a maintenance program of one exercise workout a week. Five months later, on retesting, the strength was considerably higher than the initial levels. In about half of the patients available for study at that time it remained at or near the peak level attained at the completion of the six weeks training program. This is in agreement with the results of Rose[13] and of Muller.[9]

This form of physical conditioning appears to be especially appropriate for patients too debilitated to undergo a regular progressive resistive isotonic exercise program. This technique seems suitable for patients in post-surgical convalescence, in patients with myocardial infarction, possibly after the fourth week, in those with muscular dystrophy and in those with joints too painful to tolerate conventional isotonic active or resistive exercise. For those who are "too busy to have time for exercise" it could be offered as a possible means of achieving and keeping physical fitness.

CROSS-TRANSFER OF STRENGTH

The concept of cross-transfer of learned skills and strength evolved as a result of studies by Scripture and Brown[14] published in 1894. These investigators worked mainly upon the cross-transfer of acquired skills and they conclusively proved that it occurs. Hellebrandt and coworkers,[3] Clarke, Shay and Mathews,[1] Klein,[6] Rose[13] and more recently Walters[16] all confirmed the phenomenon of cross-transfer of strength. Liberson and Asa[7] published in 1959 the results of their work, which did not agree with those of the above mentioned investigators. However, these investigators studied the cross-transfer effect on a very small and infrequently used muscle, the abductor digiti quinti, whereas the other investigators used the larger flexor and extensor groups of the arms and legs. It has been documented[2,4,15] that transfer is greatest when work has been performed in overload, and this is more feasible when the larger muscle groups are exercised.

The cross-transfer phenomenon can be put to use in cases in which an extremity is so injured that active exercise is temporarily interdicted. By exercising the contralateral extremity, gratifying increases in strength can be obtained. Then, as the pathologic process subsides, active exercise of the affected limb can be started. However, for some unexplained reason an extremity that is immobilized in a cast does not receive strength by transfer. In such a situation the use of electrical stimulation through windows in the cast or an isometric con-

traction of only one-fifth maximal strength, which is possible by employing a bivalve cast, will prevent muscle atrophy.

In the treatment of knee injuries, exercise of the affected extremity benefits the contralateral limb incidentally. When a program of exercise is undertaken in such a case, the initial strength of the corresponding limb should be assessed to establish a baseline. The cross-transfer effect begins immediately, even though the unexercised leg may be stronger than the exercised limb. When an extremity is permanently damaged, as may be the case in poliomyelitis, the two strength development curves would be approximately parallel to each other, with the strength of the affected leg increasing but still remaining at a fairly constant level below that of the unexercised well extremity. When the disease or injury is reversible and of short duration, as in meniscectomy, the injured extremity will reach the level of strength of its counterpart and at the completion of the exercise program the strength of both the exercised, injured leg and its unexercised counterpart will be considerably greater than they were before the injury.

EXERCISE DOSAGE

In writing prescriptions for therapy with ultrasonic frequencies, diathermy or ultraviolet light, physicians generally specify the dosage desired and the duration of treatment. However, when prescribing progressive resistance exercise, it is only infrequently that the physician specifies the rate at which exercise should be performed, the total number of repetitions desired and the magnitude and frequency of increments of resistance. In the absence of such instructions, the therapist may make decisions that should be made by the physician, a practice that might retard the progress of rehabilitation.

For hypothetical analysis of a progressive resistive exercise program in terms of energy cost, horsepower developed and results achieved, let it be assumed that a patient performs ten exercises of twenty repetitions each, using a 5-pound resistance. Assuming that the average excursion of the weight against gravity is 12 inches, this patient will have performed 1000 foot pounds of work. (We may disregard the energy consumed in moving the arm only, since this figure will be practically constant for each repetition in the two alternatives to be considered.) If it takes this patient 30 minutes to go through the exercise program, he is "working" at a rate of 0.001 horsepower per minute. During the actual isotonic movement he will be working at a rate eight times higher. Now, if this patient should perform the same number of exercises with only one-fourth the number of repetitions, but with twice the weight, he could go through the same program in approximately one-half the time. He would have spent half the energy, while exercising at the same overall rate of work. During the isotonic phase he will have contracted his muscle against twice the resistance. Yet his cardiovascular system is not being taxed to any greater extent. However, by creating greater demands on the muscle, yet reducing the number of repetitions, he will be achieving faster gains in strength with half the energy cost and half the time consumed. If we go one step further and consider the feasibility of using the 6-second daily maximal isometric contraction as a strength-developing technique, we will be reducing even more the work load imposed on the patient. The savings in therapist's time might also make it worth while. With a debilitated patient, this reduction in time and effort involved might be paramount.

Finally, we come to a consideration of the term *progressive*. A therapeutic exercise program can be progressive in three ways. It may involve an increase in the resistance used or the number of repetitions executed, or it may contemplate a progressive decrease in the length of time necessary to carry out the exercise program. The work of Walters[16] indicated that with higher resistance and a decreased number of repetitions, we can achieve increases in strength faster and surprisingly improve endurance also. It has also been established that small daily increments[13] are a most effective way of achieving maximum increase in the minimum time. It is also a matter of common knowledge that as physical condition improves the organism is capable of performing more work per unit of time. It seems reasonable, then, that these factors *should be given* careful consideration in the formulation of exercise programs for patients.

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REFERENCES

1. Clarke, H. H., Shay, C. P., and Mathews, D. K.: Strength and endurance effects of exhaustive exercise of the elbow flexor muscles, J. A. Phys. and Ment. Rehab., 8:184-188, 1954.

2. Gregg, R. A., Mastellone, A. F., and Gersten, J. W.: Cross exercise: a review of literature and study utilizing electromyographic techniques, Am. J. Phys. Med., 36:269-280, 1957.

3. Hellebrandt, F. A., Houtz, S. J., and Parish, A. M.: The influence of unilateral exercise on the contralateral limb, Arch. Phys. Med., 28:76-85, 1947.

4. Hellebrandt, F. A., Parrish, A. M., Partridge, M. J., and Walters, C. E.: Tonic neck reflexes in exercise of stress in man, Am. J. Phys. Med., 35:144-159, 1956.

5. Hettinger, T. H., and Muller, E. A.: Muskelleistung and Muskel-training. Arbeits Physiologic, 15:111-126, 1957.

6. Klein, K. K.: Study of cross transfer of muscular strength and endurance from progressive resistance exercise following injury, J. A. Phys. and Ment. Rehab., 9:159-161, 1955.

7. Liberson, W. T., and Asa, M. M.: Further studies of brief isometric exercises, Arch. Phys. Med., 40:330-336, 1959.

8. Mathews, D. K., and Kruse, R.: Effects of isometric and isotonic exercises on elbow muscle groups, Research Quart., 28:26-37, 1957.

9. Muller, E. A.: The regulation of muscular strength, J. A. PMR, 11:41-47, 1957.

10. Rarick, G. L., and Larsen, G. L.: Observations on frequency and intensity of isometric muscular effort in post pubescent males, Research Quart., 29:333-341, 1958.

11. Rasch, P. J., and Morehouse, L. E.: Effect of static and dynamic exercise on muscular strength and hypertrophy, J. Appl. Physiol., 1:29-34, 1957.

12. Rodriguez, M. J., DePalma, J., and Deykin, H.: Unpublished data.

13. Rose, D. L., Radzyminski, S. F., and Beatty, R. R.: Effect of brief maximal exercise on the strength of the quadriceps femoris, Arch. Phys. Med., 38:157-164, 1957.

14. Scripture, E. W., Smith, T. L., and Brown, E. M.: On the education of muscular control and power, Stud. Yale Psychol. Lab., 2:114-119, 1894.

15. Walters, C. Etta: The bilateral transfer of motor skill, Phys. Therapy Rev., 35:567-569, 1955.

16. Walters, C. Etta, Stewart, Ch. L., and Le Claire, J. F.: Effects of short bouts of isometric and isotonic contractions on muscular strength and endurance, A. J. Phys. Med., 39:131-141, 1960.